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SWIFT SYNTHESIS OF ZnO NANORODS BY MICROWAVE HYDROTHERMAL METHOD

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ABSTRACT

A new, simple, large yield, low cost, microwave assisted hydrothermal method to synthesize high quality ZnO nanorods has been adopted. The microwave assisted hydrothermal synthesis method brought significant benefits like greater speed and yield compared to the traditional methods. The present article utilized zinc acetate, sodium hydroxide solutions as precursors which exerted a tremendous effect on morphology and size of ZnO nanorods. The scanning electron microscoping (SEM), X-ray diffraction (XRD), UV Spectroscopy, FTIR analysis revealed the morphology and particle size of ZnO nanorods having around 40nanometer in diameter and 0.8micrometer in length formulate 150^{0}C with 120minutes growth time. This current method suitable for large scale production of ZnO nanorods and could be extended to metal oxide nanostructures.

KEYWORDS: ZnO Nanorods, High Yield Chemical Synthesis, Microwave Radiation & Hydrothermal Method

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Original Article

1. INTRODUCTION

ZnO nanostructures has attracted intensive research effort for its unique properties for versatile application [1]. ZnO nanorods are attracting much interest several applications such as nanophotonics [2], dye-sensitized solar cells [3, 4], electron field emitters [5, 6], field effect transistors [7] and piezotronics [8]. Among various synthesis methods the microwave assisted hydrothermal synthesis has emerged as a powerful method for the synthesis of ZnO nanorods with some significant advantages such as cost effective large yield and less complicated technique [9]. Among several oxides semiconductors ZnO nanorods is considered to the best application material than other metal oxide nanorods [10]. Therefore the development of new, simple, cost effective and large scale synthesis roots for high quality ZnO nanorods is under investigation [11]. Now a days different nanostructures like nanowires, nanocombs, nanorings, nanobridges, nanoflowers, nanoblets, nanocages [12, 13] etc., are reported to their high potential application in nano electronic devices [14].

2. EXPERIMENT

In this method ZnO Nanorods are synthesized by a 0.5Mol solution of zinc acetate dehydrate [$Zn(COOCH_3)_2(H_2O_2)$] was prepared by dissolving in 100ml of ethanol and stirred so much for 30minutes at 60^{o}C. Also 0.9M aqueous solution of sodium hydroxide (NaOH) was prepared in a similar way with stirring for 30 minutes. The 60^{o}C heated 0.9M NaOH aqueous solution was added to drop by drop(slowly for 1 hour) touching the walls of the conical flask containing zinc acetate dehydrate [$Zn(COOCH_3)_2(H_2O_2)$] solution under high constant speed stirring by magnetic stirrer. The solution turns into a jelly form and a milky white turbid

solution was obtained after 2 hours. The solution was allowed to settle for 2 hours sealed. The turbid solution was then subjected to microwave radiation at a temperature of 150^{o}C heated for 120 minutes. The product becomes fluffy inside the oven, removed and dried at room temperature and grinded, the obtained is a powder consists a mixture of ZnO Nanorods and Nanowires. The total procedure is repeated for different time durations in microwave chamber.

The growth time has also an important influence on the morphology of ZnO nanorods, nanowire in the hydrothermal process. A series of samples, of which the growth time varies from 30 minutes to 120 minutes, has been performed to better understand the growth kinetics.

3. RESULTS AND DISCUSSIONS

3.1 X-ray Diffraction Analysis

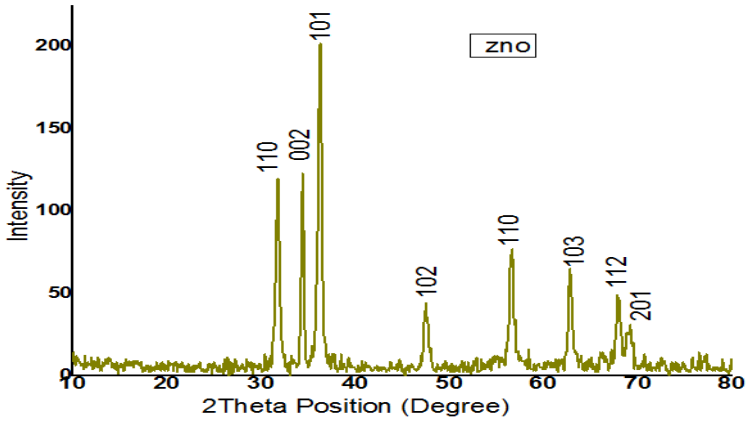

Figure 1: XRD Patterns of ZnO Nanorod

The phase and crystallinity of the synthesized sample were investigated by X-ray diffraction patterns shown in Figure 1. A number of Bragg reflections with 2θ values of 31.72^{o}, 34.30^{o}, 36.12^{o}, 47.51^{o}, 56.48^{o}, 62.75^{o}, 66.31^{o}, 67.83^{o}, 69.04^{o}, 72.44^{o} and 76.81^{o} are observed corresponds to (100), (002), (101), (102), (110), (103), (200), (112), (201), (004) and (202) planes, shows a typical XRD pattern of ZnO nanoparticles in the range of 10°-80°at a scanning rate of 1 (JCPDS card No.89.1397). The average size of the zinc oxide nanoparticles was determined as 36 nm from the width of dominating peaks (100) and (101) reflections according to the Debye - Scherrer equation. All diffraction peaks are indexed according to the hexagonal phase of ZnO Nanorods. No characteristic peaks of impurity phases except ZnO are found which revealed that good crystalline in nature of the samples.

3.2 Fourier Transform Infra-Red Spectroscopy Analysis

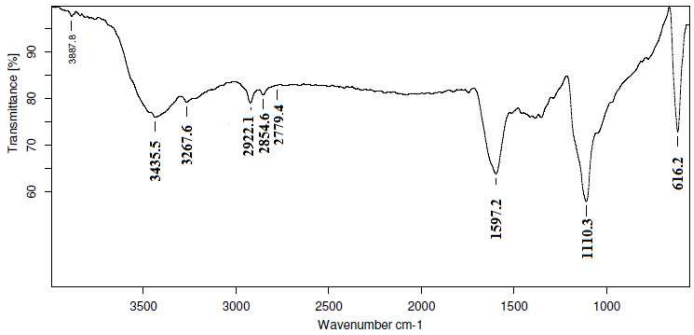

Figure 2: FTIR Spectra of ZnO Nanorod

FTIR is an effective method to reveal the composition of products. Figure 2 is a typical FTIR spectrum of pure ZnO nanoparticles, the peak at 616.2 cm^{-1}. The peaks lying from 1000 to 1600, 2500 to 2900 and 3000 to4000 cm^{-1} are representing the functional groups corresponding to C-O symmetric and anti- symmetric stretching mode, C-H stretching mode and O-H stretching mode respectively. The presence of the O-H group represents the presence of water molecules on the surface of ZnO nanorods.

3.3 Particle Size Analysis

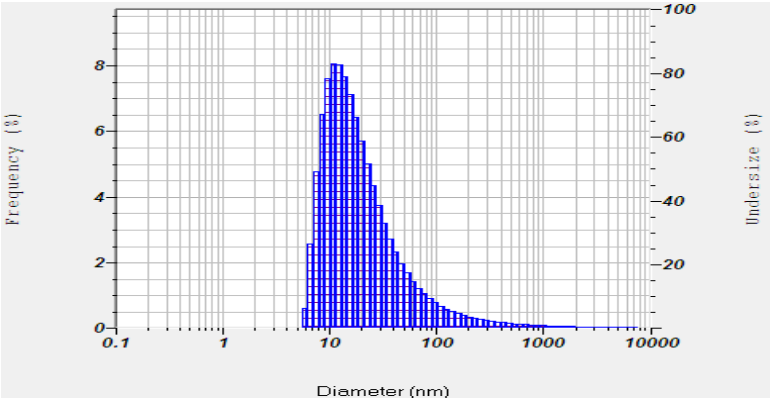

Figure 3: PSA Spectra of ZnO Nanorods

The as-prepared ZnO nanorods were ultra-sonicated and suspended in the distilled water. The measurement of particle size distribution of ZnO nanorods was done by Dynamic Light Scattering. In the prepared sample it was observed that, particle has wide size distribution; the majority of them were dispersed within a narrow range, as shown in Figure 3. The average particle size of the figure was found to be 42 nm.

3.4 Scanning Electron Microscope Analysis

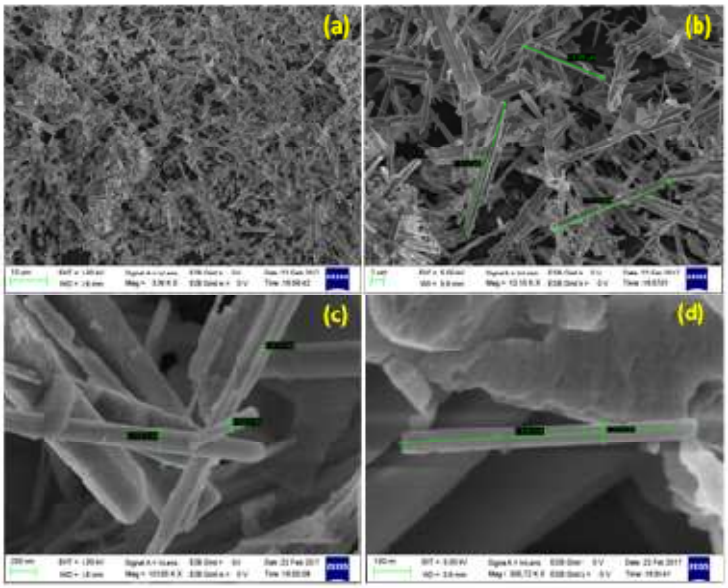

Figure 4: Figure (a) SEM Image Showing Uniform Growth of ZnO Nanorods. Figure (b and c) Shows Further Magnification (10KX) of ZnO Nanorods. Figure (d) Shows High Magnification (300KX) of Individual ZnO Nanorods with Uniform growth

The FE-SEM micrographs of the as-prepared nanorods ZnO are presented in Figure 4. From figure (a) the sample uniform growth of ZnO nanorods on further magnification (10KX) in figures (b and c) the ZnO nanorods diameter around 55nm and length is in few 0.8micometer. Closer inspection with high magnification (300KX) in figure (d) shows individual ZnO Nano rods with uniform growth.

3.5 UV-Vis Analysis

The UV absorbance spectrum of ZnO nanorods is recorded in the wavelength range 300nm-800nm. Figure 5 shows the optical absorbance spectrum of ZnO nanorods synthesized by microwave irradiation at 150^{o}C. The spectrum shows a strongest absorption peak at 380nm. The powder containing mostly ZnO Nanorods shows much higher UV absorption as compared to nanoparticle which reveals the large surface area of nanorods as compared to nanoparticle. The slight shift in the absorption may occur upon the change in particle size or particle shape.

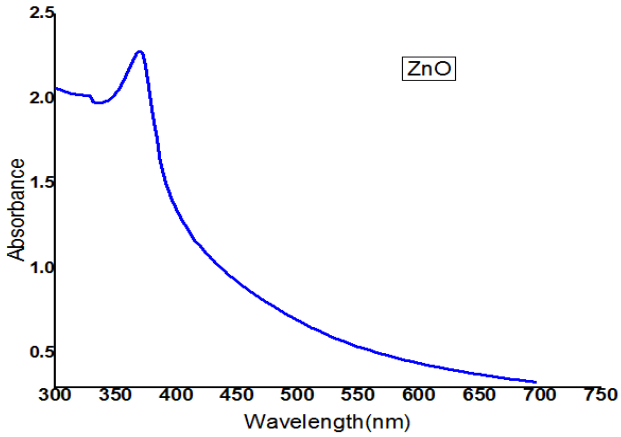

Figure 5: UV Absorbance Spectra of ZnO Nanorods

4. CONCULSIONS

The present work revealed a very simple approach for the synthesis of ZnO Nanorods by highly efficient microwave assisted hydrothermal method, which proved to be simple and reproducible for a variety of nanostructures in large scale. The XRD, PSA analysis confirms the size of ZnO Nanorods, SEM images revealed the spherical granular ZnO Nanorods, Zn-O stretching and deformation, vibration peaks were by disclosing by FTIR, and UV analysis technique confirmed the quantum size effect of ZnO Nanorods. The obtained ZnO nanorods are used in different research and industrial applications.

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